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Aquatic Plant Control Research Program

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Aquatic Vegetation Restoration in Drakes Creek, Tennessee

by Gary Owen Dick, R. Michael Smart, and Joe R. Snow

Background

The primary purpose of the Drakes Creek Section 1135 Restoration Project was to improve aquatic wildlife habitat in a floodwater conveyance. Drakes Creek is a major tributary embayment of the Old Hickory Reservoir on the Cumberland River, its mouth located at Cumberland River mile 222.2, 10 km upstream from Old Hickory Dam. The project site is located in the City of Hendersonville, Tennessee, at the limit of the Old Hickory pool, approximately 4 miles above the creek's mouth. When Old Hickory Dam was closed in 1954, the upper end of the Drakes Creek embayment began to fill with silt. By the early 1990s, exposed mud flats had become apparent. Loss of aquatic habitat generated support for applying corrective and restoration efforts. The U.S. Army Engineer District, Nashville, is managing the Federal portion of the Section 1135, with the City of Hendersonville serving as local sponsor. Two separate projects have been initiated in Drakes Creek. The first, commonly referred to as Phase 1, is located on the left descending bank of the creek immediately below the Highway 31E bridge, adjacent to Memorial Park (Figure 1). The second project, Phase 2, will extend downstream from the Highway 31E bridge for up to a mile along the middle of the creek and/or the right descending bank.

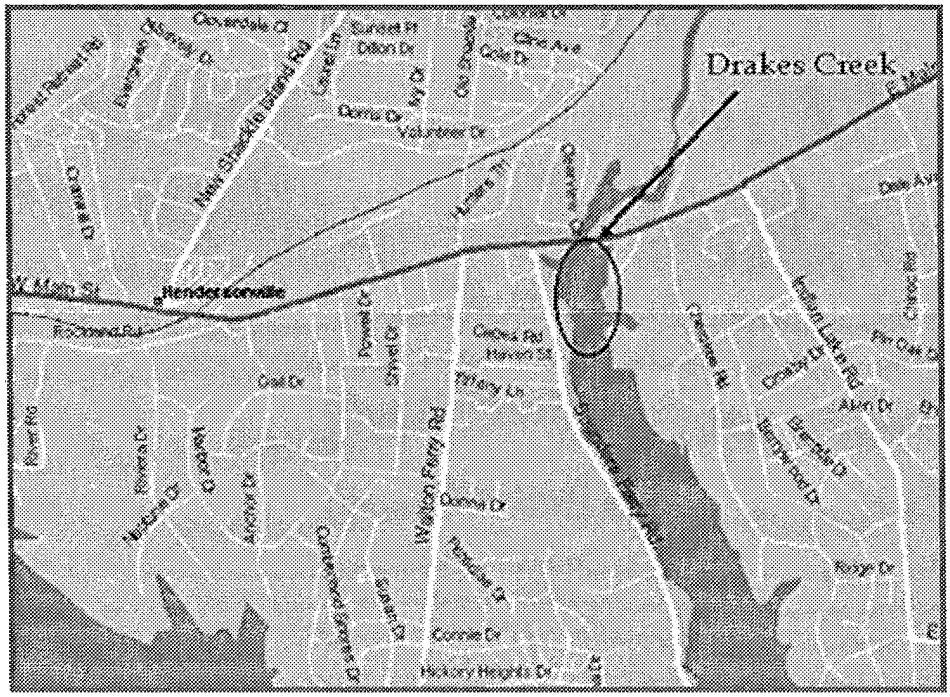

Figure 1. Drakes Creek Section 1135 restoration site

The Lewisville Aquatic Ecosystem Research Facility (LAERF), U.S. Army Engineer Research and Development Center (ERDC), participated in Phase 1 of this project, employing techniques developed for establishing native aquatic plants in man-made reservoirs. In Phase 1, geo-tubes were filled with sediments dredged from approximately 17 acres of degraded (silted-in) aquatic habitat. The geo-tubes were installed to partially isolate a portion of the creek adjacent to Memorial Park from the main channel, thereby reducing silt deposition (Figure 2).

Approaches

Site conditions were assessed and a strategy was devised to establish native plants. Being newly dredged, the site was mostly unvegetated, although water primrose (*Ludwigia* spp.) was beginning to establish along much of the shoreline. Flood control and hydroelectric generation operations generally result in stable water levels in Drakes Creek, with less than 0.3 m fluctuation under normal conditions. Waterfowl, turtles, common carp, and muskrats were identified as potential grazers of newly establishing plants.

Protective exclosures were used to reduce the impact of herbivory on newly establishing plants. Ring cages were 1-2 m diameter × 0.6 m, 1 m or 1.2 m tall open-ended cylinders constructed from 2-in × 2-in. or 2-in × 4-in. mesh, PVC-coated, welded wire. Tray cages were 1.5 m long ×1.2 m wide × 0.3 m tall exclosures constructed from 2-in. × 4-in. mesh, PVC-coated, welded wire. Both exclosure types were relatively low profile (aesthetics), durable, and effective in excluding a variety of large herbivores. Approximately 240 exclosures were constructed and installed during this project.

Additional efforts to minimize the potential impacts of herbivores included a program initiated by the City of Hendersonville to reduce resident populations of Canada geese and mallards and domestic ducks by trapping and relocation. This practice continued throughout the two-year plant establishment portion of the project.

Beginning in June 2001, Phase 1 shallow-water areas (0-1 m in depth) were planted with native plant species. Emergent, floating-leaved, and submersed plants native to Tennessee were used, including the following species:

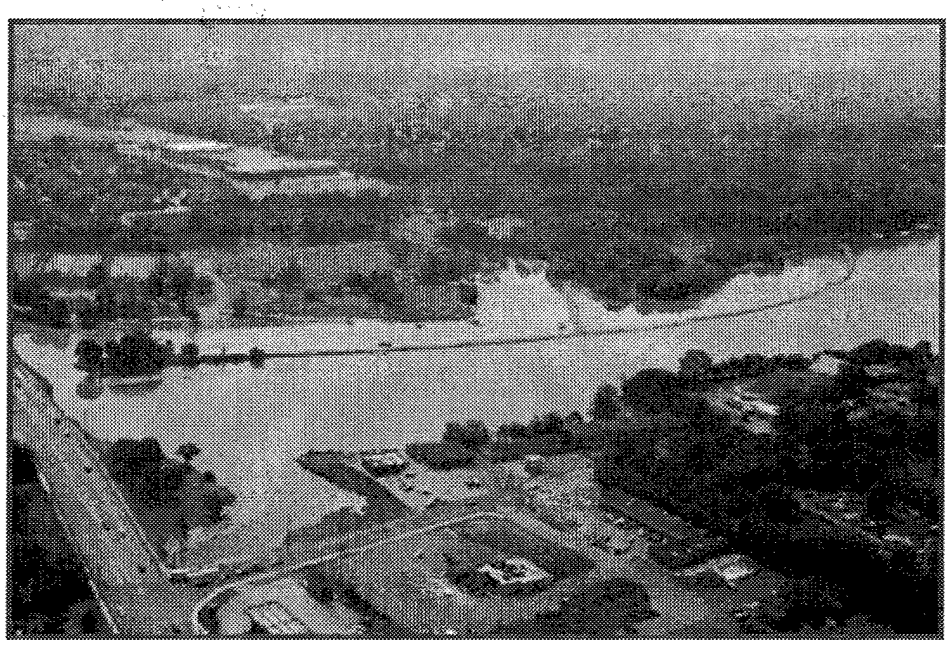

Figure 2. Aerial view of Drakes Creek restoration site (Phase 1)

- Emergent species
  - Flatstem spikerush, *Eleocharis macrostachya*
  - Slender spikerush, *E. acicularis*
  - Squarestem spikerush, *E. quadrangulata*
  - Lizard's-tail, *Saururus cernuus*
  - Arrow arum, *Peltandra virginica*
  - American bulrush, *Scirpus americanus*
  - Softstem bulrush, *S. validus*
  - Arrowhead, *Sagittaria latifolia*
  - Bulltongue, *S. graminea*
  - Pickerelweed, *Pontederia cordata*
  - Creeping burhead, *Echinodorus cordifolius*
  - Water willow, *Justicia americana* (planted in 2002)
- Submersed species
  - Wild celery, *Vallisneria americana*
  - Water stargrass, *Heteranthera dubia*
  - Southern naiad, *Najas guadalupensis*
  - Muskgrass, *Chara vulgaris*
  - American pondweed, *Potamogeton nodosus*
  - Illinois pondweed, *P. illinoensis*
- Floating-leaved species
  - White water lily, *Nymphaea odorata*

Assessments and Adaptive Management

General

Initial assessments made in September 2001, about 8 weeks following planting, indicated that most species had survived and appeared to be well-established (Figure 3). Waterfowl (ducks and geese) grazing was intense on some plants, and cages failed to protect at least four species: bulltongue, arrowhead, creeping burhead, and softstem bulrush. Additionally, one plant species selected for this project, American bulrush, appeared to be unsuitable for the site. Remaining species appeared healthy and vigorous inside cages, although spread beyond protected areas was not

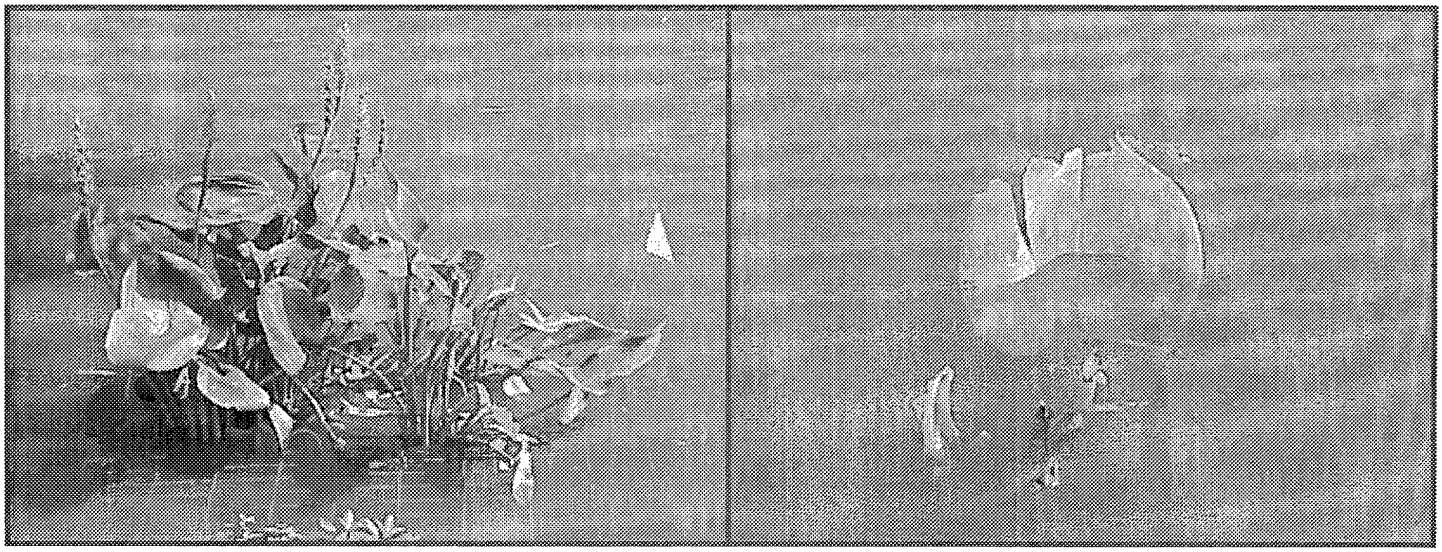

Figure 3. Most protected plants, including pickerelweed and arrow arum (left) were well-established after 8 weeks in Drakes Creek (unprotected plants suffered grazing damage, mostly by waterfowl (right))

yet noted, likely due to the short time between planting and assessment.

A second assessment in spring 2002 indicated that most plant species tested were able to withstand winter conditions, including American pondweed, Illinois pondweed, water stargrass, wild celery, white water lily, pickerelweed, flatstem spikerush, slender spikerush, squarestem spikerush, and arrow arum (Figure 4). In June 2002, cages in which plants had not survived winter, or grazing by herbivores the previous growing season, were replanted with species that had survived or with water willow (*Justicia americana*), added as a replacement for American bulrush. Additionally, small ring cages (0.5-m diameter) were constructed and planted with bulltongue, arrowhead, and creeping burhead to improve these species' survivorship since ducks evidently were able to reach into tray cages and damage stem bases and roots.

A final assessment was conducted during September 2002. Plants were doing well, in many cases better than expected, and all cages had plants within them (Figure 5). Evidence of waterfowl and muskrat grazing remained on

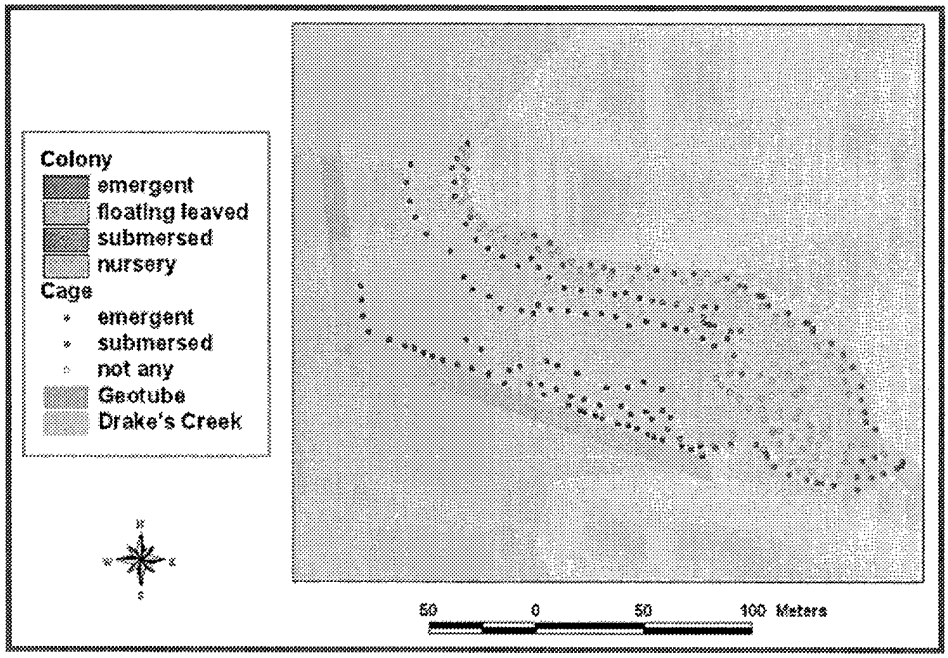

Figure 4. Map produced in 2002 from GPS coordinates illustrates exclosures and plant colonies established in Drakes Creek after one year. Most species planted with protection during 2001 survived and were present the following spring. Cages that did not support plants were replanted in June 2002

some plants, but most seemed to be withstanding effects of herbivory. Few Canada geese were observed (results of efforts to relocate them from the site), although several hundred mallard and domestic ducks were seen in the vicinity. Softstem bulrush appeared to be the most heavily impacted by muskrats grazing. Water willow, serving to replace American bulrush, was doing well, and was unaffected by grazing. Arrowhead, bulltongue, and creeping burhead had filled the small ring cages in which they were planted: this cage design was better suited than tray cages for establishing these species in Drakes Creek.

Spread beyond protected areas was noted for a number of species.

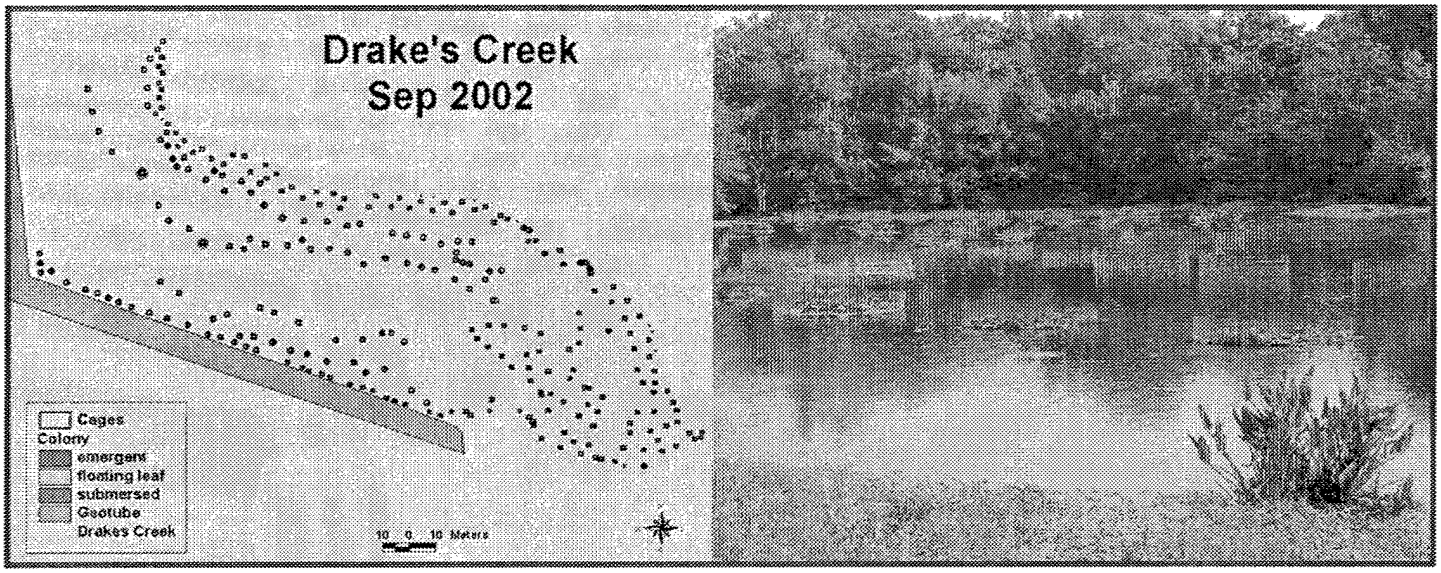

Figure 5. By September 2002, all exclosures supported plants. Many species had begun to spread beyond protected areas around cage

Species exhibiting direct growth from cages included American pondweed, Illinois pondweed, wild celery, white water lily, pickerelweed, lizard's-tail, and water willow. Unprotected growth away from cages, caused by fragmentation, included American pondweed and water stargrass. Seedlings of pickerelweed were also observed in areas protected by water primrose growth.

Cage condition

Cages and materials held integrity, and no breaches through or under cages were observed. Materials were expected to last an additional five (or more) years beyond the final assessment. High water levels apparently occurred before the site visit and water had topped over many of the ring cages, potentially allowing aquatic herbivores (common carp and turtles) access to the plants. However, no signs of herbivory by these animals were observed inside ring cages.

Individual Plant Species Results

All but one plant species, American bulrush, had successfully established and filled the cages in which they were planted. Some had begun to spread from cages.

Submersed species (all planted in ring cages):

Water stargrass (Heteranthera dubia), planted in 0.6-to 1-m water depths, exhibited vigorous growth, filling 75-100 percent of each cage in which it was planted. No signs of herbivory were noted on this species. Small colonies, apparently growing from fragments, were common in shallow waters on the outer edge of water primrose at a depth of about 0.3 m.

American pondweed (*Potamogeton nodosus*) filled 75-100 percent of each cage in which the species was planted, all at a depth of 0.6 m (Figure 6). In some cases, vegetative growth outside the cages increased colony size to twice that of the protected area. Several small colonies, apparently grown from fragments, were observed on the outer edge of the water primrose.

Wild celery (*Vallisneria americana*) survival was limited to gravelly areas, where it filled 100 percent of the cages in which

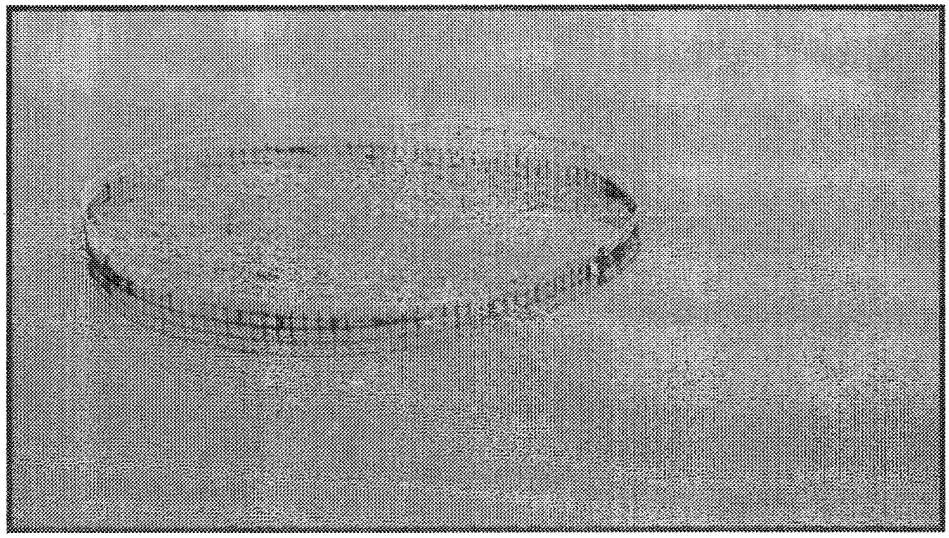

Figure 6. American pondweed was successfully established in ring cages and most colonies exhibited spread to unprotected areas

it was planted, all at a depth of 1 m. Additionally, these colonies had spread to occupy an area up to three times that of the protected area. Plants outside cages were robust, but exhibited signs of herbivory by turtles.

Illinois pondweed (*Potamogeton illinoensis*) filled 75-100 percent of each cage in which it was planted, all at a depth of 1 m. Some colonies had begun to spread outside protected areas. Signs of herbivory on plants outside cages by waterfowl and turtles were noted.

Muskgrass/southern naiad (*Chara vulgaris/Najas guadalupensis*) colonies were highly variable, with some cages completely filled by muskgrass. Southern naiad was weakly present in all cages. These were replanted with water stargrass and American pondweed in 2002. All muskgrass/southern naiad colonies were planted at a depth of 0.6 m. No signs of herbivory were observed, and poor establishment in some cages was attributed to high turbidity. Although spread of these species was not observed, many tray cages were occupied by one or both: these plants came as either volunteers in propagule sediments or from seeds/spores produced by nearby colonies.

Floating-leaved species (all planted in ring cages):

White water lilies (*Nymphaea odorata*) were robust, in all cases filling cages in which they were planted (Figure 7). Spread was observed from several cages. Signs of herbivory by waterfowl and turtles were noted on stems and leaves outside of cages.

Emergent species (planted in tray cages, except softstem bulrush):

All emergents planted were at depths of 0.1 or 0.3 m, dependent upon species.

Softstem bulrush (*Scirpus validus*) was planted at 0.3 m in both tray and ring cages, but grew slowly. New growth was heavily grazed, evidently by muskrats. The species did not survive in ring cages since muskrats climbed in and ate the rhizomes, and also did not survive in most tray cages. Of those surviving, grazing was heavy, with an estimated 75 percent or more shoots severely damaged. Its ability to survive in this system remains questionable. Those cages in which bulrush did not survive were planted with water willow.

American bulrush (*Scirpus americanus*) was planted at 0.1-m depths and most plants were very weak by the time of the fall 2001 assessment. None had survived by the spring 2002 assessment, and the species was replaced with water willow.

Water willow (*Justicia americana*) established well in tray cages in which it was planted, replacing American bulrush as well as some bulltongue, arrowhead, and creeping burhead, and had grown to fill 75-100 percent of each cage (Figure 8). In a few cases, plants were beginning to grow outside protected areas. No evidence of herbivory was noted on this species.

Bulltongue (*Sagittaria graminea*), originally planted at 0.1-m depths and protected by tray cages, did not survive, apparently due to intense grazing by waterfowl. New individuals were

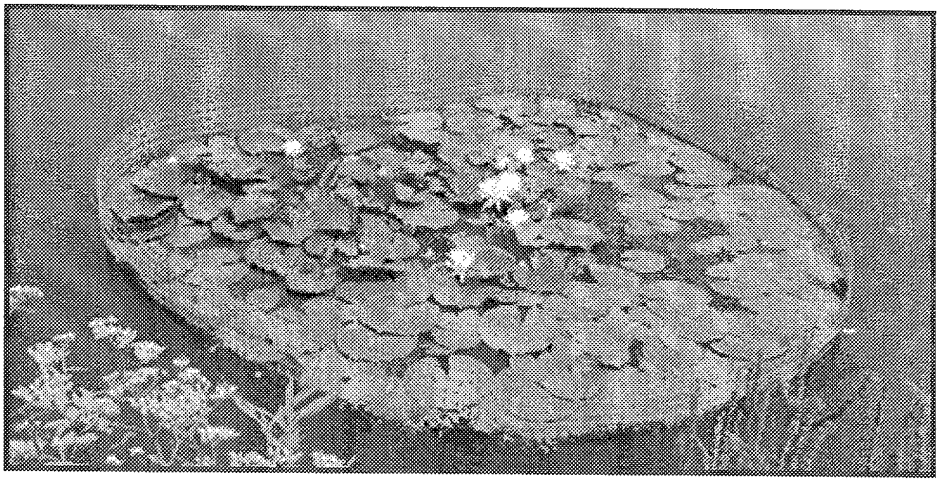

Figure 7. White water lily was successfully established in ring cages and several colonies spread to unprotected areas

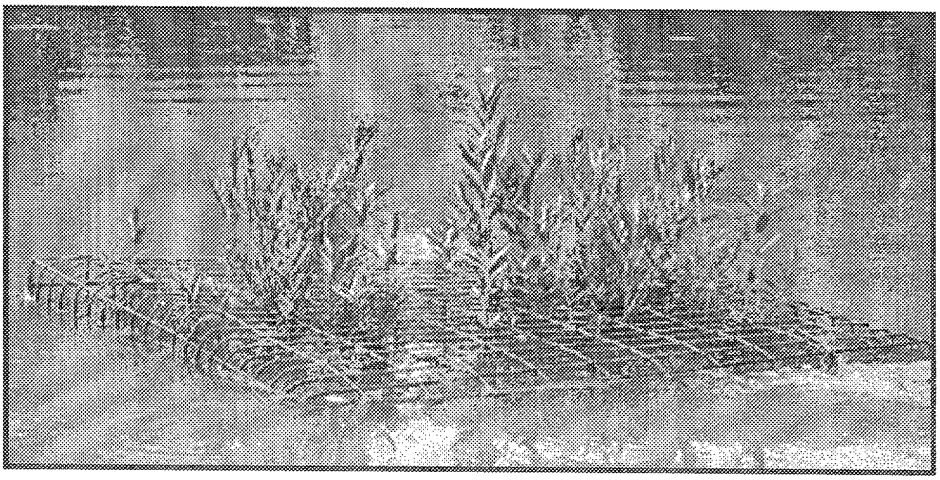

Figure 8. Water willow was used to replace plants that faired poorly in tray cages

planted in 2002 and protected with small ring cages to prevent waterfowl from reaching in and eating the roots. These plants grew vigorously and had filled the ring cages after eight weeks. Several small colonies were observed growing in water primrose patches, apparently benefiting from the masking effect of water primrose and reduced waterfowl populations.

Arrowhead (*Sagittaria latifolia*) planted in tray cages did not successfully establish in 2001, apparently due to intense grazing by waterfowl. One arrowhead plant found appeared vigorous, indicating the species is suitable for this habitat. New individuals were planted in 2002 and protected with small ring cages, preventing waterfowl from reaching in and eating the roots. These plants grew vigorously and had filled the ring cages after eight weeks. Several small, unprotected colonies were established in water primrose patches, apparently benefiting from the masking effect of water primrose and reduced waterfowl populations.

Creeping burhead (*Echinodorus cordifolius*) planted in tray cages did not establish in 2001, apparently due to intense grazing by waterfowl. New individuals were planted in 2002 and protected with small ring cages; these plants filled the ring cages after eight weeks. Spread beyond cages by creeping burhead was not observed.

Arrow arum (*Peltandra virginica*) was well established, although signs of grazing by waterfowl were noted on some leaves above the tray cages. Unprotected plants installed adjacent to the tray cages were heavily damaged by grazing, but were surviving after two years. No spread of this species was observed.

Pickerelweed (*Pontederia cordata*) was successfully established in tray cages. Signs of waterfowl herbivory were evident on some of the leaves and stems protruding above tray cages, but roots and stems below were not damaged. Several small, unprotected colonies were established in water primrose patches, apparently benefiting from the masking effect of water primrose and reduced waterfowl populations.

Flatstem spikerush (*Eleocharis macrostachya*) was growing well in tray cages and had spread to unprotected areas, particularly where water primrose was present. However, damage from waterfowl grazing was observed on some plants. Most flatstem spikerush had been overgrown by water primrose and appeared to have benefited from masking.

Slender spikerush (*Eleocharis acicularis*) had established well and exhibited some spread outside of cages. No signs of herbivory were observed on plants within or outside of cages, and while many of the slender spikerush plants had been overgrown by water primrose, it did not appear that this species required masking.

Squarestem spikerush (*Eleocharis quadrangulata*) grew well and had spread outside of some cages (in areas masked by water primrose), but was subject to intense waterfowl grazing, and in many cases tray cages failed to protect the plants. Only 10 percent of the originally planted colonies were evident by the end of two years.

Lizard's-tail (*Saururus cernuus*) was growing well inside tray cages, and no signs of herbivory were noted. Spread was not noted for this species during the two-year project.

Conclusions

Protection from herbivores was critical for establishment of most aquatic plant species in Drakes Creek. Although some plants survived without protection, those that did were relatively weak and did not produce flowers or seeds, and therefore did not contribute to spread observed. Once protected colonies were large enough, they were able to grow beyond protected areas and produce enough seed to overcome grazing pressure.

Because 18 species of native aquatic plants were successfully established during the course of this project, Drakes Creek now supports habitat beneficial to fish and other aquatic organisms. Additionally, this restored area serves as a founder colony that should supply propagules for establishment of these species in other areas within Old Hickory Reservoir.

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